PLOS CLIMATE

RESEARCH ARTICLE

"When you have stress because you don't have food": Climate, food security, and mental health during pregnancy among Bakiga and Indigenous Batwa women in rural Uganda

Julia M. Bryson[1,2]*, Kaitlin Patterson[1]*, Ashlee Cunsolo[3], Lea Berrang-Ford[4], Shuaib Lwasa[5], Didacus B. Namanya[6], Sabastian Twesigomwe[7], Charity Kesande[7], James D. Ford[4], Indigenous Health Adaptation to Climate Change Research Team¶, Sherilee L. Harper[1,8]*

1 Department of Population Medicine, University of Guelph, Guelph, Ontario, Canada, **2** Michael G. DeGroote School of Medicine, McMaster University, Hamilton, Ontario, Canada, **3** Labrador Institute of Memorial University, School of Artic & Subarctic Studies, Happy Valley-Goose Bay, Newfoundland & Labrador, Labrador City, Canada, **4** Priestley International Centre for Climate, University of Leeds, Leeds, United Kingdom, **5** Department of Geography, Geo-Informatics and Climatic Sciences, Makerere University, Kampala, Uganda, **6** Department of Community Health, Ugandan Ministry of Health, Kampala, Uganda, **7** Batwa Development Program, Buhoma, Uganda, **8** School of Public Health, University of Alberta, Edmonton, Alberta, Canada

¶ Membership of the Indigenous Health Adaptation to Climate Change research team is provided in the Acknowledgments.
* brysonj@mcmaster.ca (JMB); kaitlin.patterson@mail.mcgill.ca (KP); sherilee.harper@ualberta.ca (SLH)

OPEN ACCESS

Citation: Bryson JM, Patterson K, Cunsolo A, Berrang-Ford L, Lwasa S, Namanya DB, et al. (2024) "When you have stress because you don't have food": Climate, food security, and mental health during pregnancy among Bakiga and Indigenous Batwa women in rural Uganda. PLOS Clim 3(10): e0000399. https://doi.org/10.1371/journal.pclm.0000399

Editor: Noureddine Benkeblia, University of the West Indies, JAMAICA

Received: January 30, 2024

Accepted: August 11, 2024

Published: October 31, 2024

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: https://doi.org/10.1371/journal.pclm.0000399

Data Availability Statement: As established by the University of Guelph Research Ethics Board and as

Abstract

Climate change exerts wide-ranging and significant effects on global mental health via multi-factorial pathways, including food insecurity. Indigenous Peoples and pregnant women inequitably experience the harms associated with climate change and food insecurity. This study explores food security and maternal mental health during pregnancy among rural Ugandan Bakiga and Indigenous Batwa women in the context of climate change. Using a community-based research approach, we conducted a series of focus group discussions about climate, food security, and health during pregnancy in four Indigenous Batwa communities and four Bakiga communities in rural Kanungu District, Uganda, as well as longitudinal follow up interviews later in the year. Data were evaluated using a qualitative thematic analysis. Women consistently identified mental health as an important factor affecting maternal-fetal wellbeing during pregnancy. Many women identified that weather and climate extremes, such as prolonged droughts and unpredictable weather events, have made it more difficult for them to obtain sufficient food for themselves and their families during pregnancy, resulting in significant mental distress. More extreme weather conditions have made physical labour difficult or impossible during pregnancy, and resultant hunger further decreased ability to obtain food—a vicious cycle. Women described how anxiety was compounded by worry about future famine, as they anticipated further decreases in crop yields and rising food prices in a changing climate. Indigenous Batwa women experienced additional distress around their lack of access to Indigenous lands and its nutritious food sources. Overall, mothers in rural Uganda described food insecurity and climate extremes

per the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans, due to the in-depth and unique opinions and experiences expressed in qualitative interviews, and the small population sizes of the Batwa communities, it is not possible to de-identify our qualitative transcripts. Consequently, and at the request of Batwa communities, we are unable to provide de-identified data and researchers are unable to request access to the data for secondary use. Please contact the University of Guelph Research Ethics Board (reb@uoguelph.ca) for further details.

Funding: Financial support was provided by a University of Guelph (www.uoguelph.ca) Summerlee travel scholarship awarded to JMB; a Frederick Banting Doctoral Graduate Scholarship (Canadian Institutes of Health Research, cihr-irsc.gc.ca), an International Development Research Centre (www.idrc.ca) doctoral research award, and a University of Guelph (www.uoguelph.ca) Summerlee research grant awarded to KP; and a Canadian Institutes of Health Research (cihr-irsc.gc.ca) grant awarded to SLH, LBF, SL, DBN, JDF and the IHACC Research Team. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

as major sources of stress during pregnancy, and they anticipate challenges will worsen. Interventions to enhance adaptive capacity to climate change are needed and should have a focus on the intricate connections with food insecurity and mental health as drivers of overall maternal health.

Introduction

The effects of climate change on mental health are an important global public health challenge [1–4]. For example, increased weather and climate extremes, such as floods, hurricanes, droughts, and wildfires, are linked with depression, anxiety, and post-traumatic stress disorder [2,4–10]. For millions of people, forced displacement and migration due to climate-related environmental destruction or resource depletion is emotionally traumatic and can increase sensitivity to other stressors [2,11]. Further, ecological grief from climate change is a growing issue, and encompasses the distress people feel in relation to physical ecological losses, disruption of place-based knowledge and sense of self, and anticipation of future environmental loss as a result of climate change [3,12]. Yet despite the gravity of mental health issues associated with climate change, these issues are often underrepresented in the literature compared to physical health challenges [13–15].

Notably, climate change can impact mental health via direct and indirect impacts on food security [4,16]. Food availability, accessibility, nutrient value, and stability are projected to decline globally due to climate change [16–19]. The health consequences are likely to be most severe in regions where climate change exacerbates already high levels of undernutrition [1,19,20], such as sub-Saharan Africa, where the prevalence of undernutrition is 22.8%—the highest in the world and climbing [21]. The association between food security and mental well-being has been described for many populations, including in sub-Saharan Africa [22–28]. People facing food insecurity consistently express feelings of stress, anxiety, despair, hopelessness, and shame about their challenges getting enough food [29–31]. Quantitatively, multiple analyses have found dose-response relationships between food insecurity and lower scores on mental health indices [23,25]. Pregnant women have particularly high sensitivity to food insecurity [32]. Hunger has been described as "the most potent physical and psychological stressor for women across the globe" [33]. Indeed, increased antenatal nutritional needs [34], combined with increased difficulty of obtaining food when pregnant [35,36], poses a significant challenge which is highly influenced by seasonality and climate [37–39]. Food insecurity during pregnancy has been strongly associated with increased maternal stress, depression, and mental illness across multiple populations [2,40–45]. Considering climate change is linked to increasing severity of food security challenges [18,19,21,32], it is reasonable to anticipate an associated increase in mental health morbidity [23,25], which may be further exacerbated during pregnancy. However, there is minimal research addressing the interactions between climate, seasonality, food insecurity, and mental health [24,46], and even less focused on the experience of women during pregnancy.

Indigenous Peoples have documented several climate change impacts on their food systems [47–50]. Factors such as land dispossession, colonialism, and discrimination are at the root of these challenges, increase climate change risks, and make it more difficult for Indigenous Peoples to adapt [10,48,51–54]. There is a small but growing body of research exploring the impacts of climate change on mental health in Indigenous Peoples which has documented increased stress, anxiety, sadness, and grief associated with changes in the land, restricted

abilities to participate in Indigenous practices, and isolation and loss of sense of place [7,55–62]. Several studies have identified connections between climate and food insecurity or climate and mental health among Indigenous Peoples [8,57,59,60,63–71], but exploring this intersection was the main objective of only one study [72]. Furthermore, there is a large research gap on climate change and mental health for Indigenous Peoples in Africa [8], despite the strong impacts of climate change and food insecurity in this region [20].

Herein, we examine food security and maternal mental health during pregnancy among rural Ugandan Bakiga and Indigenous Batwa women in the context of climate change. Specific objectives were to document and characterize: 1) pathways by which food security affects mental wellbeing during pregnancy; 2) influences of seasonality and climate change on maternal mental health directly and via food insecurity; and 3) unique experiences of Indigenous mothers navigating the intersection of pregnancy, climate, food, and mental health.

Methods

Partner communities

Kanungu District, in southwest Uganda, is home to approximately 252,000 people [73]. Nearly 700 Batwa people live in the area, with the Bakiga ethnic group composing most of the remaining population. The Batwa are an Indigenous Peoples who hunted and gathered in the forest until the creation of Bwindi Impenetrable National Park led to their forced eviction from traditional lands without compensation in the 1990s [51,74]. They have since been denied virtually all access to the forest, barring them from access to traditional foods and medicines, and disrupting their spiritual connection to the land [74,75]. The forced transition to an agrarian lifestyle has been difficult for the Batwa, contributing to inequities in several areas. Regarding physical health, Batwa experience higher rates of under-five mortality [51], acute gastrointestinal illness [76], malaria [77,78], and pregnancy loss [79] compared to local or national averages. Food security is a major challenge, with 97% of Batwa households identified as food insecure, one of the highest rates in the published literature [47]. As a consequence, undernutrition is significantly higher among Batwa compared to the neighbouring Bakiga communities [80]. The Bakiga participate mostly in farming, both subsistence and cash crops, in addition to limited work opportunities in the tourism industry [47]. Some Bakiga landowners employ Batwa labourers [47]. The Bakiga experience similar health and food security challenges as the Batwa, but with lower magnitude, extent, and frequency [79–81]. There is a lack of research about mental health in these communities; however, experiences of land displacement and resulting stressors are likely to have impacted mental wellbeing for the Batwa [47,51,82], like many other Indigenous Peoples.

The local food systems in Batwa and Bakiga communities mainly consist of subsistence agriculture (crops and small livestock such as goats) with some cash cropping [47,81]. Farming is physically demanding, almost entirely accomplished by manual labour. Bananas, maize, beans, and potatoes are the main crops in the area. Cash crops also include tea and coffee. There is limited access to large markets and most food is consumed or traded locally [81]. In the dry season when agriculture yields are low, household food needs are supported by trading with other farms and engaging in manual labour in exchange for food or cash to purchase food at local markets [47]. Manual labour available in the area is generally low-paying, including cleaning, cooking, digging in the fields, collecting tea, making bricks, and selling handicrafts [47].

Approach to research

A community-based adaptation research approach was used for this work [83], and partner community members were involved in all stages of the research process. This approach aimed

to ensure that research was mutually beneficial, collaborative, and rooted in long-term relationships [83]. Batwa community members engaged in this study to identify priority research questions in the context of climate change and health [51,81]. In addition, two local community organizational partners were engaged: the Batwa Development Program, a local non-governmental organization which focuses on Batwa community wellbeing; and Bwindi Community Hospital, which serves over 100,000 people in Kanungu District. Maternal health was identified as a research priority, which served as the impetus for this study and others [79]. These community and organizational partners were involved in defining research questions, data collection, preliminary data interpretation, validation of results, and results dissemination and sharing.

Ethics statement

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the University of Guelph Research Ethics Board (REF #16MY016), Makerere University School of Social Sciences Research Ethics (REF #MAKSS REC 04 17 044), and the Uganda National Council for Science and Technology (REF #SS 4334). Written or verbal informed consent was obtained from all participants. Verbal consent was witnessed and formally recorded.

Conceptual framework

The conceptualization of mental health for the purposes of this work was based on the framework developed by Kirmayer and Valasskakis [84] and adapted by Cunsolo Willox et al. in the context of Inuit mental health [56]. For the purposes of this work, mental health was understood as "a broad territory that includes well-being, everyday problems in living associated with bodily symptoms of stress and anxiety, mild depression, and seasonal fluctuations in mood and energy, as well as more severe psychiatric disorders, such as major depression, bipolar disorder, schizophrenia, and other psychotic disorders," [56,84]. Further, mental health was acknowledged as a dynamic individual experience that fluctuates continuously along a spectrum of wellbeing; it is affected by complex, intersecting factors including socioeconomic status, social support networks, culture, mental illness, physical health, food security, environment, and adaptability and resilience, among others [56]. Sense of place and connection to the land and land-based ways of life also contribute to mental health, as described elsewhere, for instance, in Northern Canada and the Australian Wheatbelt [3]. The risks posed to mental health as a consequence of climate change were conceptualized as a function of climate-related hazards and the exposure and vulnerability of affected people [10].

Data-gathering methods

Ten partner communities in Kanungu District shared their experiences on maternal health and climate (Fig 1). A series of eight focus group discussions (FGDs) were conducted in May and June 2017: four in Indigenous Batwa communities and four in geographically matched neighbouring Bakiga communities, involving a total of 24 Batwa and 22 Bakiga women ranging in age from 18 to elderly. These communities are variable distances from both Bwindi Impenetrable National Park (which can impact land fertility and microclimates) and Bwindi Community Hospital (which can impact access to healthcare) and thus represent varying experiences living in the region. All FGDs were conducted with the support and invitations of local chairpersons, who co-led contacting and inviting women to participate in research and coordinating data collection. FGDs were conducted within each community, where women felt comfortable, to lessen some of the power imbalances that existed between the researchers and

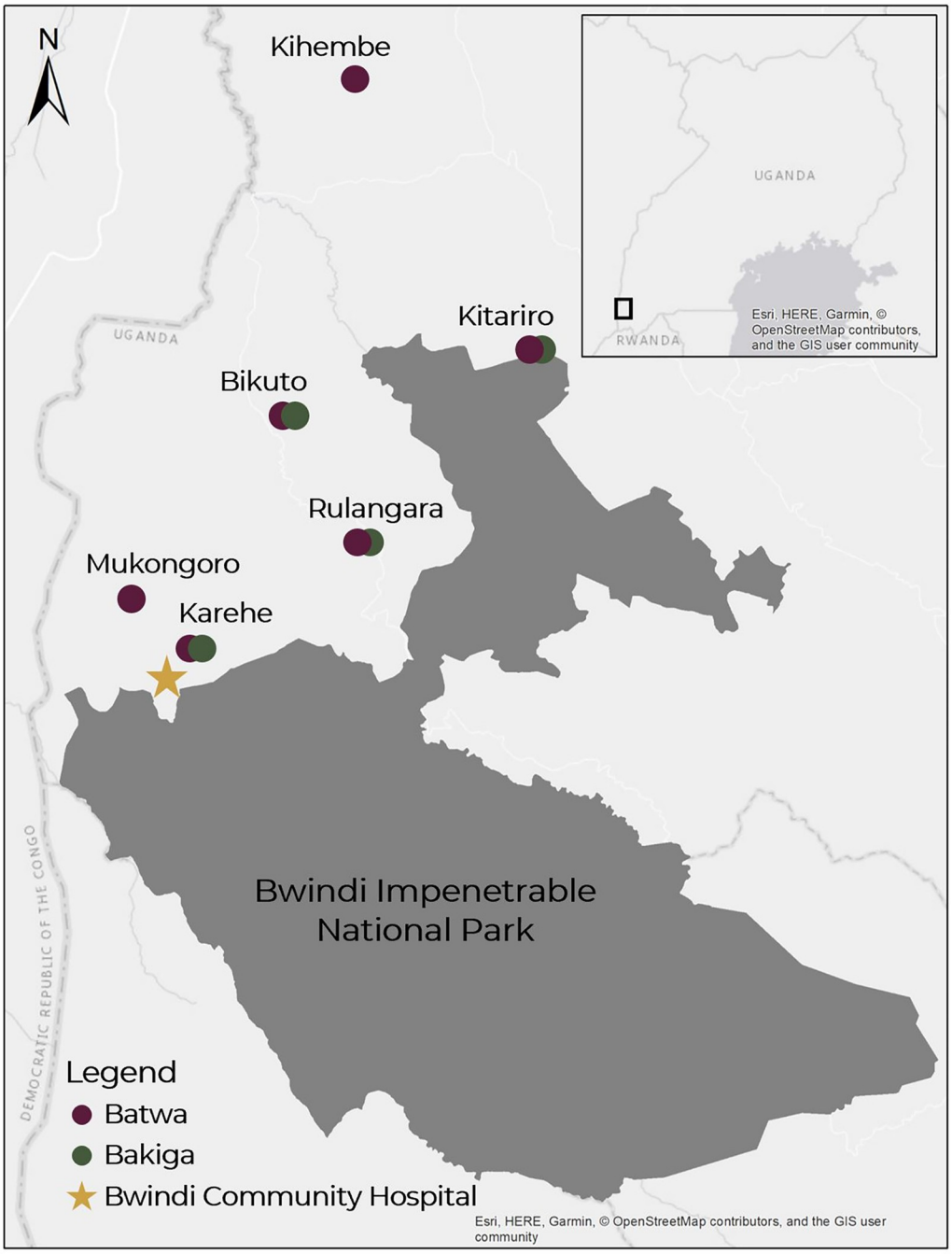

Fig 1. Map of partner communities in Kanungu District, Uganda, which engaged in focus group discussions on maternal health and climate. Not to scale. Base map and data from OpenStreetMap and OpenStreetMap Foundation. Available from https://www.arcgis.com/home/item.html?id=d1255ac5efac4508b34579bf8979708c.

https://doi.org/10.1371/journal.pclm.0000399.g001

participants. Batwa communities of varying population size and geographical distance from Bwindi Impenetrable Forest and Bwindi Community Hospital interested in participating were invited to represent a wide range of life experiences in Kanungu District. Within communities, women of diverse ages from 18 to elderly engaged in each FGD to ensure that experiences with pregnancy over several decades were represented. All women having at least one current or

previous pregnancy were eligible to participate in the FGDs. FGDs were conducted in English with simultaneous translation to the local language (Rukiga) by an experienced local research associate, who obtained informed consent. All FGDs were audio-recorded with informed consent.

A semi-structured, conversational style was used for FGDs, whereby a guide of several predetermined questions (available upon request of authors) was used to elicit conversation and women were able to further direct the conversation in whichever directions they felt to be most important. Major FGD topics included impacts of food security on health during pregnancy, influences of climate on food security and health, and changes in maternal-infant health over time. As women brought up new topics, the discussion guide was updated in an iterative process so that these participant-identified areas of interest could be discussed in other communities [85]. Of note, the theme of climate-related mental health challenges was entirely emergent from early FGDs, as the discussion guide initially did not explicitly prompt participants to consider mental wellbeing but rather health generally. As mental health was quickly highlighted by women as an important part of their pregnancies to discuss, it was incorporated into FGDs. Additional information on antenatal maternal mental health was gathered in FGDs in two Batwa communities from April to December 2017 to learn more about their experiences with pregnancy in a longitudinal manner.

Data analysis

The data generated in the FGDs were analyzed via a qualitative thematic analysis (Fig 2) [86,87]. NVivo 10 was used to facilitate manual coding of the data, quotation retrieval, and overall data organization including comparison of the Batwa and Bakiga experiences. Direct quotes that informed the themes are drawn upon in the paper.

Peer debriefing [88] was conducted frequently during data collection and analysis with local experts (e.g. Bwindi Community Hospital physicians, Batwa community members), research colleagues who have worked alongside the partner communities, and the team of local researchers to gain insight into preliminary findings and later to confirm the themes. These consultations involved both informal discussions and formal sessions. Gathering of information from a diverse group of knowledge-holders allowed for triangulation of information, which improved authenticity and validity in qualitative analysis [88]. In addition, prolonged engagement and partnership with community members also contributed greatly to the validity of the research [88].

Results

The information shared by mothers on their experiences with mental health, climate change, and food security during pregnancy can be integrated under three main themes: 1) Pregnancy-specific stressors challenged maternal mental health and were compounded by food insecurity; 2) Inequities exacerbated food security stressors for Indigenous mothers; and 3) Seasonality and environmental exposures can influence mental health during pregnancy.

Pregnancy-specific stressors challenged maternal mental health and were compounded by food insecurity

In every community where mental health was discussed, stress, anxiety, or sadness during pregnancy was an important concern with connections to food security and climate (Fig 3). The experience of pregnancy itself was associated with a baseline level of increased stress for many women, in addition to climate and food security related stressors. Some communicated that the state of being pregnant often causes mental distress in this context, saying sadness

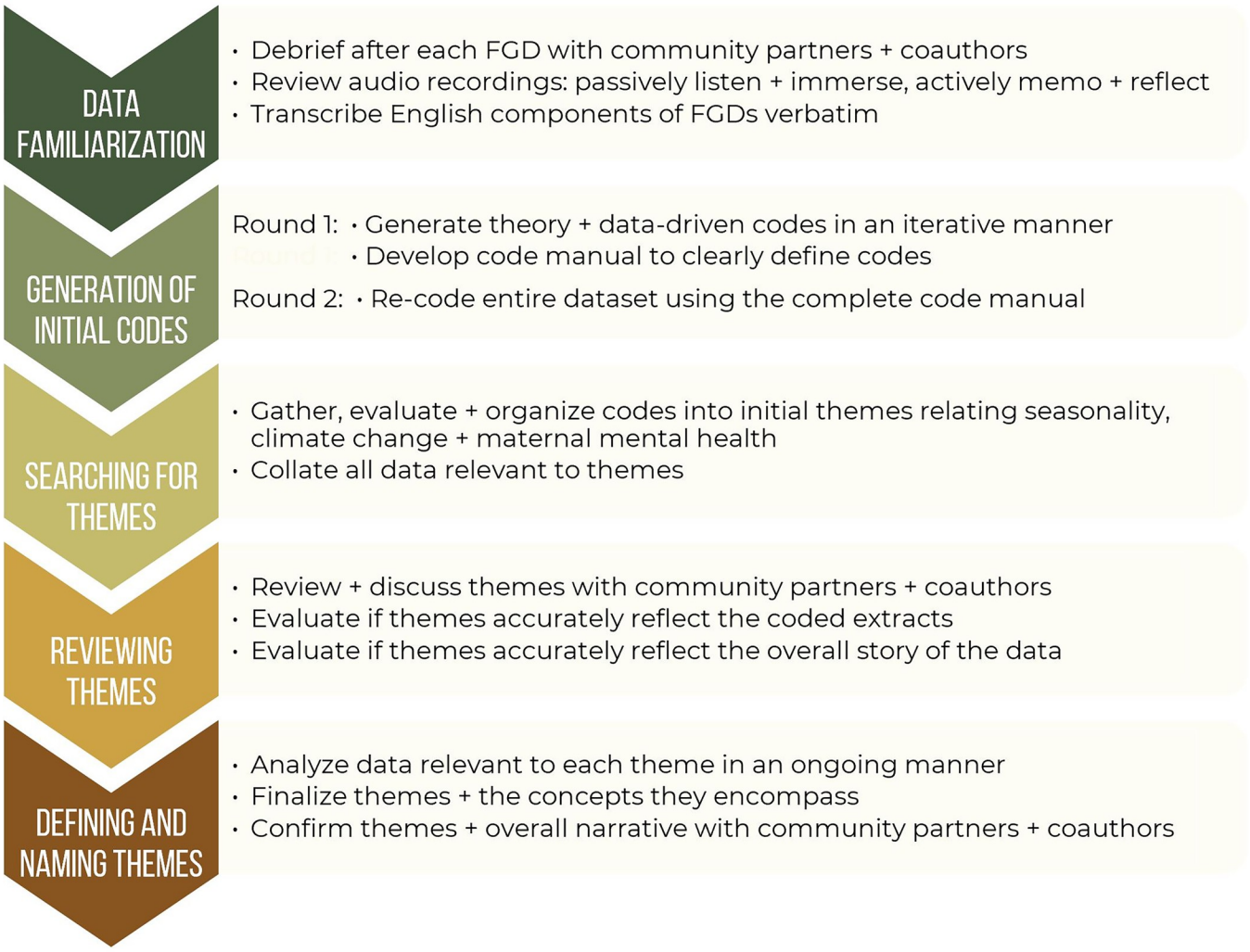

Fig 2. Qualitative thematic analysis methods used to analyze focus group discussion data relating climate and maternal mental health during pregnancy. FGD = Focus group discussion.

https://doi.org/10.1371/journal.pclm.0000399.g002

comes *"because of being pregnant."* Many women associated maternal stress with the health risks of being pregnant, and outcomes such as miscarriages and still births were distressing in these communities. As a Batwa woman explained, *"You feel sad because of all that time carrying a pregnancy and it is lost."* The challenge of poor food security was a significant source of stress during pregnancy, as women often bore the majority or totality of the responsibilities of providing food for the family. The issues of food availability and accessibility caused significant struggle in Indigenous Batwa communities for almost all women. Women explained that nutrient-dense foods like rice and meat, which they often crave during pregnancy, were especially hard to obtain due to cost.

Manual digging and harvesting in the fields were often required of women to obtain food. This work is strenuous, especially in challenging environmental conditions like heavy rain and extreme heat. Women described the difficulty of the work increasing when pregnant and the ability to cope with harsh weather waning, yet the need to provide food persisting. Consequently, decreased ability to perform physical labour while pregnant was associated with poor food security and mental wellbeing. As one woman explained,

Fig 3. Concept map of pathways by which weather, climate, food security, and daily stressors interact to impact maternal mental health. Adjacent icons have direct connections.

https://doi.org/10.1371/journal.pclm.0000399.g003

We are depressed and we are stressed, because when we are pregnant we find we don't have energy to go and work and get what we want. We find we depend on begging.

Thoughts about the future consequences of not having the energy to work and get food for the family while pregnant were also distressing:

You see other people going to prepare food for the future, and you are weak. . . You start thinking in the future you won't have food and others will have food.

Since more children meant greater demand for food and money for essentials like school fees, the workload and stress of the mother's provider role increased with family size. As one Batwa woman said, *"I'm producing many children [and] every responsibility is on me."* For some women, social support was available when they were unwell and unable to support their family while pregnant, explaining, *"When we are sick the men have to take over."* But for others, *"We don't get help at all."* The mental distress associated with the provider role was described to affect physical health as well: *"I find I become sick—like having a headache—because of the stress of looking for food to cook for the children, and I can't find any."*

Women from Bakiga communities also faced challenges with food insecurity during pregnancy. Like Batwa women, Bakiga women were typically the main provider of food for the family, which was a source of stress. For example, a woman discussed the possibility of children taking risks because of their mother's inability to provide for them during pregnancy, saying women can be "*scared*" thinking that *"your kids are going to go and steal somewhere because you're not working, you're not finding [food] for them. . .or you are going to fail to get school fees."* Some women worried about the impacts of their stress on their fetus, saying *"when you have stress because you don't have food. . .you can produce a small baby, or you produce the baby before term."*

However, although Bakiga women described facing similar challenges to Batwa women, they were reported on a different level of severity. Whereas Batwa women reported struggling to obtain any food at all or eating only one staple starch for weeks on end, women from a Bakiga community described being stressed about not being able to access specific foods they desired during the pregnancy, explaining,

We have food, but sometimes maybe if you feel that you want a certain type of food and you can't afford to get it at the moment, you can be stressed.

Hence, relatively food-secure women still experienced stress during pregnancy related to food, even if their experience was different than those with severe food insecurity. Regardless of the differences between Bakiga and Indigenous Batwa, when asked if mothers worry about not getting enough food while pregnant, a Bakiga woman emphatically replied *"Yes. So much."*

Inequities exacerbated food security stressors for Indigenous mothers

While both Batwa and Bakiga women experienced stress related to food and climate, the Indigenous Batwa women described additional sensitivity attributable to expulsion from their traditional lands in the forest. Women explained that when the Batwa lived as hunter-gatherers they had a bountiful supply of food from the forest, including *"honey," "wild yams," "pig,"* and *"Uganda kobs [antelope]."* Older women who had once lived in the forest described the relative ease of getting these nutritious foods in the past, saying, *"Before when we were in the forest we would think of eating meat, and we would be craving meat, and we would get it. But now when we are pregnant, we pray for good foods. . .but we can't get them."* Outside of the forest, farming has been difficult. Foods like meat and fish were too expensive for most Batwa to purchase, which meant for some women *"You find even throughout the pregnancy you can get meat like once."* These descriptions of food inaccessibility were in stark contrast to the food availability of the past, and the injustice can be heightened during pregnancy and the antenatal period when nutrient-dense food was said to be craved but unattainable. In one Batwa community, a

woman expressed how pregnant women are physically weaker now because their access to the forest is cut off, saying women in the past *"had strong immunity because the type of food they used to eat from the forest."* This elderly woman also lamented the loss of access to traditional medicines, saying *"These young mothers, they never took the local herbs from the forest. . .so even their babies are born weak because the mothers are not strong."*

Seasonality and environmental exposures can influence mental health during pregnancy

Dealing with environmental health exposures during pregnancy was described as stressful by both Bakiga and Indigenous Batwa mothers. A Bakiga woman shared that she had a lot of sad thoughts in the dry season because *"I'm always not feeling well, as if I'm going to have a miscarriage."* She explained that the sunshine in the dry season made her feel very hot all the time, which she worried could harm her baby. These feelings of malaise related to weather in pregnancy, including both cold rainy conditions and hot dry conditions, negatively impacted ability to work for food. For example, a Batwa woman explained *"In the dry season because there is a lot of sunshine, no food, all the time you feel hot. . . You find you are stressed because of that."* A Bakiga woman added that, when you are pregnant,

> *Your mood usually changes because in the dry season you find you don't even have enough food. If the dry season is prolonged, so there is no food, you are worried because your children don't have enough food to eat.*

Droughts were particularly arduous, and women reported them to be increasing in length and frequency. The rainy season also presented barriers to food availability when extreme weather such as strong wind, rain, or hailstorms damaged crops. Furthermore, the seasons were described as changing and unpredictable, which heightened challenges faced in agriculture and consequent stress related to food security. In one Batwa community where the cultural tourism industry was an important source of income, the rainy season was associated with more stress related to food accessibility as tourism decreased and women felt they had less energy to work when pregnant during the rains. And while some women did not feel season significantly impacted their mental wellbeing, most agreed that being pregnant reduced their ability to manage environmental exposures which impacted their mental health. Many also felt that food security was a major determinant of their ability to adapt to harsher environmental conditions; if they had more food, they would feel healthier while pregnant and be better able to keep up with their normal activities, even in challenging weather.

Although the Bakiga women reported better ability to cope with food insecurity, when asked how the difficulty of obtaining food while pregnant has changed over time, they were concerned about the future:

> *We are thinking even in the future that the famine is going to be high because we are experiencing a lot of insects which are destroying our crops. At least every type of crop now has a disease. . . We don't have an income, yet things are going high [becoming expensive]. Buying posho* [*a staple cornmeal] from the shop, it's very hard—it's expensive yet we don't have any income. . . and our crops are not growing well. So, we are thinking in the future it will be very hard to get food.*

Overall, the women's projections for the future consistently lacked hope for better food security.

Discussion

This study described how challenges with food insecurity and climate are common experiences during pregnancy that are associated with stress, sadness, and worry for Bakiga and Indigenous Batwa mothers in rural Uganda. Indeed, the negative impacts of food insecurity on mental health have been well-established in the general literature [89], and there is growing evidence of the negative impacts of climate change on mental health [8,10,90,91]. Our work advanced this understanding by providing qualitative research that aimed to understand the pathways through which food insecurity, climate, and mental health intersect for pregnant mothers, given their heightened sensitivity to these challenges. Especially considering physical health has been emphasized to a greater degree than mental health in the climate change-health literature [13–15], our work addresses both an underrepresented topic and emphasizes women and Indigenous voices, whose perspectives have historically been neglected.

Batwa and Bakiga mothers identified strong connections between their experiences of food insecurity and mental health struggles during pregnancy. This is consistent with quantitative research for both pregnant women [45,92] and mothers more broadly [40,46,93], which has demonstrated positive associations between food insecurity scores and indices of depression, anxiety, and other mental illness. Food insecurity is a universally taxing experience, but women in the communities described several other gendered sources of stress, including providing for children and fear of poor pregnancy outcomes, that contributed to a greater baseline stress level during pregnancy. Further, weather and climate extremes, such as heavy rains, extreme heat, and droughts, were described as sources of stress for mothers via their impacts on physical wellness and food security. Each additional stressor draws from a mother's overall mental health resiliency and decreases her available reserves to mediate further negative emotional effects of challenges such as climate change; this is the concept of allostatic load, whereby cumulative acute and chronic pressures leave a physiological and psychological stamp on the body that limits future adaptive capacity to stressors [94,95]. Higher allostatic loads have been linked to socioeconomic health disparities [94,95], indicating that the same socioeconomic factors which contribute to mental health stressors can also entrench it. Thus, weather and climate exposures that affect food security can exert even stronger influences on mental health during a time of increased cumulative stress like pregnancy.

The stressor of food insecurity often falls disproportionately on women, who, like Batwa and Bakiga mothers, are responsible for the majority of household food acquisition in many communities [96,97]. During pregnancy, the challenges of strenuous physical labour in subsistence agriculture were magnified for Batwa and Bakiga women, yet they lacked alternative means of procuring food; this reported struggle to provide for themselves and their family led to increased mental distress, meanwhile the associated undernutrition made it even harder to work to obtain food, resulting in an unforgiving cycle of maternal health challenges and food insecurity well-described by mothers [38]. Challenging weather conditions like drought and extreme heat compounded this stress. Indeed, the relationship between food insecurity and mental illness was bidirectional among low-income pregnant South African women, in that food insecurity increased the odds of having a mental illness and having a mental illness increased the odds of food insecurity [45]. For Batwa and Bakiga mothers, the stress of food insecurity was not solely focused on their own health but that of their children as well, born and unborn. Women were concerned their mental stress during pregnancy could cause low birth weight or preterm delivery of their infants, both of which have been linked to antenatal depression and anxiety with greater magnitude of association in lower income nations [98]. Considering the odds of neonatal death are 3.8 times greater

among babies with low birth weight in Uganda [99], improving maternal mental health during pregnancy could have important impacts on reducing neonatal deaths.

Mothers also described stress around keeping their children fed while they were pregnant. This is common source of distress for mothers in their role as household provider; in South Africa, women described high levels of depression, anxiety, shame, guilt, and anger associated with the inability to consistently provide food for their children, saying "{crying} 'Everybody asks me for a piece of bread and then I don't have for them,'" and, "'It makes me feel uneasy. How am I going to get it, where am I going to get it? I think about the day of tomorrow as well. . .[what] am I going to do if the children don't have milk?'" [97]. Lacking social support in times of food insecurity was an issue for some Batwa and Bakiga mothers–a lost opportunity for adaptive capacity that others utilized to persevere through difficult periods in pregnancy. In northern Uganda, the association between food insecurity and depression was stronger for those with lower social support [92]. Interventions which work to build new and strengthen existing support networks for pregnant women facing food insecurity may help to improve maternal mental health and could warrant prioritization for both research and public health programming.

Women from all communities described weather, seasonality, and climate factors which directly and indirectly contributed to psychological distress during pregnancy. Although the impacts of climate change on mental wellbeing have been well documented for the overall global population [8,10,90,91], there is an absence of research focused on these effects during pregnancy. Direct climate impacts identified by Batwa and Bakiga mothers included weather exposures such as heat which made them feel physically unwell and consequently worry about the health of their fetus. Importantly, these women have noted that challenging weather exposures are becoming more frequent and longer in duration over time [38], which indicates that while the weather events described in this work are generally short-lived and isolated experiences, their evolving nature is defining of climate change.

Indirectly, weather exposures made working for food in the fields difficult during pregnancy, contributing to food insecurity and the accompanying stress. Women described changes in climate over time, particularly longer and more frequent droughts and greater seasonal unpredictability, that have limited their agricultural yields and cause fear and anxiety that the burden of hunger will be even greater in the future. Indeed, dry periods and extreme precipitation events are projected to increase in the region [100–104]. It is therefore crucial that interventions that aim to improve food security are climate-informed to see long-term sustainable benefits. Alternative income-generating activities are one such intervention that could strengthen adaptive capacity for mothers via decreasing dependence on the land for food. Some Batwa women were already involved in the tourism industry; this may improve their ability to adapt to conditions such as longer dry seasons, which are tourist high seasons and therefore times of higher food security [38]. Overall, our results indicate that increasing climate change resiliency is likely to have beneficial impacts for both food security and maternal mental wellbeing; research that identifies strategies for climate change adaptive capacity and public health interventions that implement identified strategies could have robust benefits for mental health in these communities, in addition to the physical maternal-child health benefits.

The Indigenous Batwa mothers described more severe challenges with the stress of food insecurity, much of which was related to their forced expulsion from their ancestral lands and traditional forest way of life. This reported disparity is consistent with findings of significantly higher undernutrition among Batwa women (45.86% vs. 0.42% and 3.00% vs. 0% prevalence of moderate acute malnutrition and severe acute malnutrition, respectively, among Batwa vs. Bakiga adult women) [80]. Less agricultural experience, land ownership, land access and

agricultural inputs have been identified as barriers to food security by the Batwa [38]; these sensitivities to food insecurity are direct consequences of land dispossession, a common experience of Indigenous Peoples globally which limits health and climate change adaptive capacity [47,105,106]. Batwa Elders who participated in FGDs lamented new mothers prevented from eating nutritious traditional foods and medicines once abundant in the forest from which they have been barred for decades [74]. One Elder left a FGD early in frustration after describing her observations that young mothers and their babies are weaker than in the past because they cannot access these forest foods and medicines. There is a strong sense of loss here, especially for mothers, despite the emotional vocabulary being difficult to translate, or being culturally inappropriate.

Sense of place is intimately related to health and wellbeing for Indigenous Peoples, and when connection or attachment to place is eroded, emotional responses of sadness, anxiety, anger, and grief are common [55]. The injustice of unfair compensation for their land dispossession, continuing lack of representation at decision-making tables, and discrimination [107] are additional burdens that can mentally and spiritually tax Batwa mothers, adding to the stresses of pregnancy and negatively impacting their mental health overall. Our results suggest that interventions, including policy change, which focus on secure and just land access for the Batwa are important not only for food security, as acknowledged by the United Nations 2030 Agenda for Sustainable Development [108], but also for the direct and indirect impacts on maternal mental health.

Although on a population level the Batwa struggled more significantly with food insecurity, there remained individual Bakiga women who had severe challenges. As well, for women who worried about lack of access to specific foods during pregnancy (meat, for example), the subjective experience of food insecurity was nonetheless stressful, despite their ability to access food in general. Thus, maternal nutrition interventions would be useful in all communities, while acknowledging higher levels of support are warranted in Indigenous Batwa communities where the needs are broader and more acute. Furthermore, when food security and climate change adaptation interventions are implemented, the impact on mental health should be considered in all stages from program development to impact evaluation, given its importance to overall wellbeing as identified by mothers broadly. While this work highlights the need to better support mothers, it also highlights that they have developed expertise in adaptation that should be sought out, valued, and integrated into interventions for maternal mental health and wellbeing.

Conclusions

This study provided evidence that the interactions between climate, food insecurity, and maternal mental health are numerous, nuanced, and interconnected. For Bakiga and Indigenous Batwa mothers in rural Uganda, food insecurity was a significant source of stress, sadness, and worry during pregnancy. Forced displacement from traditional forest lands has resulted in additional barriers to both food security and mental wellbeing for Indigenous Batwa mothers. Women identified climate hazards, including drought and heat as mental health stressors, both directly and via their impacts on food insecurity during pregnancy. Furthermore, mothers were concerned that food insecurity will continue to worsen as regional climatic changes have threatened their agricultural livelihoods; the impacts on antenatal depression and anxiety could be significant. Interventions to improve climate change adaptive capacity should thus be implemented considering the heightened sensitivity of pregnant mothers and their children to the impacts of food insecurity and mental health challenges, with special attention for Indigenous mothers who have additional sensitivities for negative outcomes.

The 2015 Uganda National Climate Change Policy includes considerations for the impacts of climate change on food security and health generally, but makes no mention of mental health [109]. In 2023, Uganda began developing a National Adaptation Plan for climate change with the support of the UN Environment Programme [110]; it is imperative given the findings of our work and others' that the impact of climate change on mental health and its intersections with food security and pregnancy be integrated in this plan. Further, the consultation of Indigenous women and mothers in development of these policies would add a valuable depth of knowledge from lived experience and expertise. Despite the threats to maternal-child health posed by climate change and food insecurity, mothers have continued to demonstrate strength and leadership, and with additional supports they can better overcome the challenges they face in a changing climate.

Supporting information

S1 Checklist. Inclusivity in global research.
(DOCX)

Acknowledgments

We are deeply grateful to our partner communities for their contributions to this research. We especially thank the mothers who took the time to share their experiences with us. We value the opportunity to listen to women and Indigenous voices. We also sincerely thank our partner organizations in Uganda: Bwindi Community Hospital, the Batwa Development Program, the District of Kanungu Government, and the Ugandan Ministry of Health.

The Indigenous Health Adaptation to Climate Change Research Team includes Lea Berrang-Ford, Cesar Carcamo, Victoria Edge, James Ford, Patricia Garcia, Sherilee Harper, Alejandro Llanos, Shuaib Lwasa, and Didacus Namanya.

Author Contributions

Conceptualization: Julia M. Bryson, Kaitlin Patterson, Ashlee Cunsolo, Lea Berrang-Ford, Shuaib Lwasa, Didacus B. Namanya, Sabastian Twesigomwe, Charity Kesande, James D. Ford, Sherilee L. Harper.

Data curation: Julia M. Bryson, Kaitlin Patterson, Shuaib Lwasa, Didacus B. Namanya, Sabastian Twesigomwe, Charity Kesande.

Formal analysis: Julia M. Bryson, Kaitlin Patterson, Shuaib Lwasa, Didacus B. Namanya, Sabastian Twesigomwe, Charity Kesande, James D. Ford, Sherilee L. Harper.

Funding acquisition: Kaitlin Patterson, Lea Berrang-Ford, Shuaib Lwasa, Didacus B. Namanya, James D. Ford, Sherilee L. Harper.

Investigation: Kaitlin Patterson, Sabastian Twesigomwe, Charity Kesande.

Methodology: Julia M. Bryson, Kaitlin Patterson, Lea Berrang-Ford, Charity Kesande, Sherilee L. Harper.

Project administration: Julia M. Bryson, Kaitlin Patterson, Shuaib Lwasa, Didacus B. Namanya, Sabastian Twesigomwe, Charity Kesande, Sherilee L. Harper.

Resources: Kaitlin Patterson, Lea Berrang-Ford, Shuaib Lwasa, Didacus B. Namanya, Sherilee L. Harper.

Supervision: Kaitlin Patterson, Sherilee L. Harper.

Validation: Julia M. Bryson, Kaitlin Patterson, Charity Kesande, James D. Ford, Sherilee L. Harper.

Visualization: Julia M. Bryson, Sherilee L. Harper.

Writing – original draft: Julia M. Bryson.

Writing – review & editing: Julia M. Bryson, Kaitlin Patterson, Ashlee Cunsolo, Lea Berrang-Ford, Shuaib Lwasa, Didacus B. Namanya, Sabastian Twesigomwe, Charity Kesande, James D. Ford, Sherilee L. Harper.

References

1. Watts N, Amann M, Ayeb-Karlsson S, Belesova K, Bouley T, Boykoff M, et al. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. The Lancet. 2018; 391:581–630. https://doi.org/10.1016/S0140-6736(17)32464-9 PMID: 29096948
2. Clayton S, Manning C, Krygsman K, Speise M. Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. Washington, D.C.: American Psychological Association and ecoAmerica; 2017.
3. Cunsolo A, Ellis NR. Ecological grief as a mental health response to climate change-related loss. Nat Clim Chang. 2018 Apr 1; 8(4):275–81.
4. Harper SL, Cunsolo A, Clayton S. Including mental health as part of climate change impacts and adaptation assessment: A critical advance in IPCC AR6. PLOS Climate. 2022; 1(5):e0000033.
5. Patz JA, Frumkin H, Holloway T, Vimont DJ, Haines A. Climate change: Challenges and opportunities for global health. JAMA. 2014; 312(15):1565–80. https://doi.org/10.1001/jama.2014.13186 PMID: 25244362
6. Watts N, Adger N, Agnolucci P, Blackstock J, Byass P, Cai W, et al. The Lancet Commissions health and climate change: policy responses to protect public health. The Lancet. 2015; 386:1861–914.
7. Dodd W, Scott P, Howard C, Scott C, Rose C, Cunsolo A. Lived experience of a record wildfire season in the Northwest Territories, Canada. Canadian Journal of Public Health. 2018; 109:327–37. https://doi.org/10.17269/s41997-018-0070-5 PMID: 29981098
8. Middleton J, Cunsolo A, Jones-Bitton A, Wright CJ, Harper SL. Indigenous mental health in a changing climate: a systematic scoping review of the global literature. Environmental Research Letters. 2020; 15:053001.
9. Cunsolo A, Harper SL, Minor K, Hayes K, Williams KG, Howard C. Ecological grief and anxiety: the start of a healthy response to climate change? Lancet Planet Health. 2020 Jul 1; 4(7):e261–3. https://doi.org/10.1016/S2542-5196(20)30144-3 PMID: 32681892
10. IPCC. Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Pörtner HO, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, et al., editors. Cambridge, UK and New York, NY, USA: Cambridge University Press; 2022.
11. Shultz JM, Rechkemmer A, Rai A, McManus KT. Public Health and Mental Health Implications of Environmentally Induced Forced Migration. Disaster Med Public Health Prep. 2018;1–7.
12. Ojala M, Cunsolo A, Ogunbode CA, Middleton J. Anxiety, worry, and grief in a time of environmental and climate crisis: A narrative review. Annual Review of Environment and Resources. 2021; 46:10.1–10.24.
13. Hayes K, Poland B. Addressing mental health in a changing climate: Incorporating mental health indicators into climate change and health vulnerability and adaptation assessments. Int J Environ Res Public Health. 2018; 15(9):1806. https://doi.org/10.3390/ijerph15091806 PMID: 30131478
14. Berrang-Ford L, Sietsma AJ, Callaghan M, Minx JC, Scheelbeek PFD, Haddaway NR, et al. Systematic mapping of global research on climate and health: a machine learning review. Lancet Planet Health. 2021 Aug 1; 5(8):e514–25. https://doi.org/10.1016/S2542-5196(21)00179-0 PMID: 34270917
15. Harper SL, Cunsolo A, Babujee A, Coggins S, De Jongh E, Rusnak T, et al. Trends and gaps in climate change and health research in North America. Environ Res. 2021; 199:111205. https://doi.org/10.1016/j.envres.2021.111205 PMID: 33961824
16. Cissé G, McLeman R, Adams H, Aldunce P, Bowen K, Campbell-Lendrum D, et al. Health, Wellbeing, and the Changing Structure of Communities. In: Pörtner HO, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, et al., editors. Climate Change 2022: Impacts, Adaptation and Vulnerability Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on

Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press; 2022. p. 1041–170.

17. FAO, IFAD, UNICEF, WFP, WHO. The State of Food Security and Nutrition in the World 2022. The State of Food Security and Nutrition in the World 2022. Rome: FAO; 2022.
18. Springmann M, Mason-D'Croz D, Robinson S, Garnett T, Godfray HCJ, Gollin D, et al. Global and regional health effects of future food production under climate change: A modelling study. The Lancet. 2016; 387(10031):1937–46. https://doi.org/10.1016/S0140-6736(15)01156-3 PMID: 26947322
19. Wheeler T, von Braun J. Climate change impacts on global food security. Science. 2013 Aug 2; 341 (6145):508–13. https://doi.org/10.1126/science.1239402 PMID: 23908229
20. Trisos CH, Adelekan IO, Totin E, Ayanlade A, Efitre J, Gemeda A, et al. Africa. In: Pörtner HO, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, et al., editors. Climate Change 2022: Impacts, Adaptation and Vulnerability Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press; 2022. p. 1285–455.
21. FAO, ECA, AUC. 2019 Africa Regional Overview of Food Security and Nutrition. Accra; 2020.
22. Nasung Atuoye K, Luginaah I. Food as a social determinant of mental health among household heads in the Upper West Region of Ghana. Soc Sci Med. 2017; 180:170–80. https://doi.org/10.1016/j.socscimed.2017.03.016 PMID: 28360010
23. Na M, Miller M, Ballard T, Mitchell DC, Hung YW, Melgar-Quiñonez H. Does social support modify the relationship between food insecurity and poor mental health? Evidence from thirty-nine sub-Saharan African countries. Public Health Nutr. 2018;1–8. https://doi.org/10.1017/S136898001800277X PMID: 30394250
24. Cole SM, Tembo G. The effect of food insecurity on mental health: Panel evidence from rural Zambia. Soc Sci Med. 2011 Oct 1; 73(7):1071–9. https://doi.org/10.1016/j.socscimed.2011.07.012 PMID: 21852028
25. Jones AD. Food insecurity and mental health status: A global analysis of 149 countries. Am J Prev Med. 2017 Aug 1; 53(2):264–73. https://doi.org/10.1016/j.amepre.2017.04.008 PMID: 28457747
26. Sweetland AC, Pala AN, Mootz J, Chien-Wen Kao J, Carlson C, Oquendo MA, et al. Food insecurity, mental distress and suicidal ideation in rural Africa: Evidence from Nigeria, Uganda and Ghana. International Journal of Social Psychiatry. 2019; 65(1):20–7. https://doi.org/10.1177/0020764018814274 PMID: 30479180
27. Perkins JM, Nyakato VN, Kakuhikire B, Tsai AC, Subramanian S V., Bangsberg DR, et al. Food insecurity, social networks and symptoms of depression among men and women in rural Uganda: A cross-sectional, population-based study. Public Health Nutr. 2018; 21(5):838–48. https://doi.org/10.1017/S1368980017002154 PMID: 28988551
28. Trudell JP, Burnet ML, Ziegler BR, Luginaah I. The impact of food insecurity on mental health in Africa: A systematic review. Soc Sci Med. 2021; 278:113953. https://doi.org/10.1016/j.socscimed.2021.113953 PMID: 33971482
29. Weaver LJ, Hadley C. A Systematic Review of the Evidence Linking Food Insecurity and Mental Health in Developing Countries. Ecol Food Nutr. 2009; 48(4):263–84.
30. Moreno-Black G, Guerrón-Montero C. Speaking of Hunger and Coping with Food Insecurity: Experiences in the Afro-Ecuadorian Highlands. Ecol Food Nutr. 2005; 44(5):391–420.
31. Piaseu N, Belza B, Shell-Duncan B. Less Money Less Food: Voices from Women in Urban Poor Families in Thailand. Health Care Women Int. 2004; 25(7):604–19. https://doi.org/10.1080/07399330490458141 PMID: 15487480
32. Bezner Kerr R, Hasegawa T, Lasco R, Bhatt I, Deryng D, Farrell A, et al. Food, fibre and other ecosystem products. In: Pörtner HO, Roberts DC, Tignor M, Poloczanska ES, Mintenbeck K, Alegría A, et al., editors. Climate Change 2022: Impacts, Adaptation and Vulnerability Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press; 2022. p. 713–906.
33. Pike IL, Patil CL. Understanding women's burdens: Preliminary findings on psychosocial health among Datoga and Iraqw women of northern Tanzania. Cult Med Psychiatry. 2006 Sep; 30(3):299–330. https://doi.org/10.1007/s11013-006-9022-2 PMID: 17048095
34. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, De Onis M, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. The Lancet. 2013; 382 (9890):427–51. https://doi.org/10.1016/S0140-6736(13)60937-X PMID: 23746772
35. Peterman A, Wen Ng S, Palermo T, Emma Lee IH. Managing the double burden: Pregnancy and labor-intensive time use in rural China, Mexico, and Tanzania. Stud Fam Plann. 2013; 44(4):411–30. https://doi.org/10.1111/j.1728-4465.2013.00367.x PMID: 24323660

36. Grace K, Lerner AM, Mikal J, Sangli G. A qualitative investigation of childbearing and seasonal hunger in peri-urban Ouagadougou, Burkina Faso. Popul Environ. 2017 Jun 2; 38(4):369–80. https://doi.org/10.1007/s11111-016-0268-5 PMID: 29937612

37. Blakstad MM, Smith ER. Climate change worsens global inequity in maternal nutrition. Vol. 4, The Lancet Planetary Health. 2020. p. e547–8. https://doi.org/10.1016/S2542-5196(20)30246-1 PMID: 33278369

38. Bryson JM, Patterson K, Berrang-Ford L, Lwasa S, Namanya DB, Twesigomwe S, et al. Seasonality, climate change, and food security during pregnancy among indigenous and non-indigenous women in rural Uganda: Implications for maternal-infant health. PLoS One. 2021; 16(3):e0247198. https://doi.org/10.1371/journal.pone.0247198 PMID: 33760848

39. Stevens B, Watt K, Brimbecombe J, Clough A, Judd J, Lindsay D. The role of seasonality on the diet and household food security of pregnant women living in rural Bangladesh: a cross-sectional study. Public Health Nutr. 2017; 20(1):121–9. https://doi.org/10.1017/S136898001600183X PMID: 27573667

40. Woldetensay YK, Belachew T, Biesalski HK, Ghosh S, Lacruz ME, Scherbaum V, et al. The role of nutrition, intimate partner violence and social support in prenatal depressive symptoms in rural Ethiopia: community based birth cohort study. BMC Pregnancy Childbirth. 2018; 18:374. https://doi.org/10.1186/s12884-018-2009-5 PMID: 30219050

41. Ayyub H, Sarfraz M, Mir K, Salam F. Association Of Antenatal Depression And Household Food Insecurity Among Pregnant Women: A Crosssectional Study From Slums Of Lahore. Journal of Ayub Medical College Abbottabad. 2018; 30(3):366–71. PMID: 30465367

42. Hromi-Fiedler A, Bermúdez-Millán A, Segura-Pérez S, Pérez-Escamilla R. Household food insecurity is associated with depressive symptoms among low-income pregnant Latinas. Matern Child Nutr. 2011; 7:421–30. https://doi.org/10.1111/j.1740-8709.2010.00266.x PMID: 20735732

43. Jebena MG, Taha M, Nakajima M, Lemieux A, Lemessa F, Hoffman R, et al. Household food insecurity and mental distress among pregnant women in Southwestern Ethiopia: a cross sectional study design. BMC Pregnancy Childbirth. 2015; 15:250. https://doi.org/10.1186/s12884-015-0699-5 PMID: 26449375

44. Tsai AC, Tomlinson M, Scott Comulada W, Rotheram-Borus MJ. Food insufficiency, depression, and the modifying role of social support: Evidence from a population-based, prospective cohort of pregnant women in peri-urban South Africa. Soc Sci Med. 2016; 151:69–77. https://doi.org/10.1016/j.socscimed.2015.12.042 PMID: 26773296

45. Abrahams Z, Lund C, Field S, Honikman S. Factors associated with household food insecurity and depression in pregnant South African women from a low socio-economic setting: a cross-sectional study. Soc Psychiatry Psychiatr Epidemiol. 2018; 53(4):363–72. https://doi.org/10.1007/s00127-018-1497-y PMID: 29445850

46. Hadley C, Patil CL. Food Insecurity in Rural Tanzania Is Associated with Maternal Anxiety and Depression. American Journal of Human Biology. 2006; 18:359–68. https://doi.org/10.1002/ajhb.20505 PMID: 16634017

47. Patterson K, Berrang-Ford L, Lwasa S, Namanya DB, Ford J, Twebaze F, et al. Seasonal variation of food security among the Batwa of Kanungu, Uganda. Public Health Nutr. 2017 Jan 13; 20(01):1–11. https://doi.org/10.1017/S1368980016002494 PMID: 27619162

48. Hofmeijer I, Ford JD, Berrang-Ford L, Zavaleta C, Carcamo C, Llanos E, et al. Community vulnerability to the health effects of climate change among indigenous populations in the Peruvian Amazon: a case study from Panaillo and Nuevo Progreso. Mitig Adapt Strateg Glob Chang. 2013 Oct 26; 18(7):957–78.

49. Loring PA, Gerlach SC. Food, culture, and human health in Alaska: an integrative health approach to food security. Environ Sci Policy. 2009; 12:466–78.

50. Ford JD, King N, Galappaththi EK, Pearce T, McDowell G, Harper SL. The Resilience of Indigenous Peoples to Environmental Change. One Earth. 2020 Jun 19; 2(6):532–43.

51. Berrang-Ford L, Dingle K, Ford JD, Lee C, Lwasa S, Namanya DB, et al. Vulnerability of indigenous health to climate change: A case study of Uganda's Batwa Pygmies. Soc Sci Med. 2012; 75(6):1067–77. https://doi.org/10.1016/j.socscimed.2012.04.016 PMID: 22703884

52. Ford JD. Vulnerability of Inuit food systems to food insecurity as a consequence of climate change: a case study from Igloolik, Nunavut. Reg Environ Change. 2009 Jun 22; 9(2):83–100.

53. Jones R, Bennett H, Keating G, Blaiklock A. Climate change and the right to health for Māori in Aotearoa/New Zealand. Health Hum Rights. 2014; 16(1):54–68.

54. Ford JD. Indigenous health and climate change. Am J Public Health. 2012; 102(7):1260–6. https://doi.org/10.2105/AJPH.2012.300752 PMID: 22594718

55. Cunsolo Willox A, Harper SL, Ford JD, Landman K, Houle K, Edge VL, et al. "From this place and of this place:"‘ Climate change, sense of place, and health in Nunatsiavut, Canada." Soc Sci Med. 2012; 75:538–47.

56. Cunsolo Willox A, Harper SL, Ford JD, Edge VL, Landman K, Houle K, et al. Climate change and mental health: an exploratory case study from Rigolet, Nunatsiavut, Canada. Clim Change. 2013; 121:255–70.

57. Rigby CW, Rosen A, Berry HL, Hart CR. If the land's sick, we're sick: The impact of prolonged drought on the social and emotional well-being of Aboriginal communities in rural New South Wales. Australian Journal of Rural Health. 2011 Oct; 19(5):249–54. https://doi.org/10.1111/j.1440-1584.2011.01223.x PMID: 21933367

58. Hunter E. "Radical hope" and rain: climate change and the mental health of Indigenous residents of northern Australia. Australasian Psychiatry. 2009; 17(6):445–52. https://doi.org/10.1080/10398560903062927 PMID: 20001364

59. Harper SL, Edge VL, Ford J, Willox AC, Wood M, Research Team I, et al. Climate-sensitive health priorities in Nunatsiavut, Canada. BMC Public Health. 2015; 15:605. https://doi.org/10.1186/s12889-015-1874-3 PMID: 26135309

60. Cunsolo Willox A, Harper SL, Edge VL, Landman K, Houle K, Ford JD. The land enriches the soul: On climatic and environmental change, affect, and emotional health and well-being in Rigolet, Nunatsiavut, Canada. Emot Space Soc. 2013 Feb 1; 6:14–24.

61. Petrasek MacDonald J, Cunsolo Willox A, Ford JD, Shiwak I, Wood M, IMHACC Team, et al. Protective factors for mental health and well-being in a changing climate: Perspectives from Inuit youth in Nunatsiavut, Labrador. Soc Sci Med. 2015 Sep 1; 141:133–41. https://doi.org/10.1016/j.socscimed.2015.07.017 PMID: 26275362

62. Middleton J, Cunsolo A, Pollock N, Jones-Bitton A, Wood M, Shiwak I, et al. Temperature and place associations with Inuit mental health in the context of climate change. Environ Res. 2021 Jul; 198:111166. https://doi.org/10.1016/j.envres.2021.111166 PMID: 33857460

63. Pearce M, Eagle L, Low D, Schurmann A. Cut from "Country": The Impact of Climate Change on the Mental Health of Aboriginal Pastoralists. Australasian Journal of Regional Studies. 2015; 21(1):50–79.

64. Pearce T, Smit B, Duerden F, Ford JD, Goose A, Kataoyak F. Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada. Polar Record. 2010; 46(237):157–77.

65. Sakakibara C. "No whale, no music": Iñupiaq drumming and global warming. Polar Record. 2009; 45 (235):289–303.

66. Beaumier MC, Ford JD. Food Insecurity among Inuit Women Exacerbated by Socioeconomic Stresses and Climate. J Public Health (Bangkok). 2010; 101(3):196–201.

67. Mercer N, Hanrahan M. "Straight from the heavens into your bucket": domestic rainwater harvesting as a measure to improve water security in a subarctic indigenous community. Int J Circumpolar Health. 2017; 76(1):1312223. https://doi.org/10.1080/22423982.2017.1312223 PMID: 28422581

68. Heaney AK, Winter SJ. Climate-driven migration: an exploratory case study of Maasai health perceptions and help-seeking behaviors. Int J Public Health. 2016; 61:641–9. https://doi.org/10.1007/s00038-015-0759-7 PMID: 26552667

69. Ford JD, Beaumier M. Feeding the family during times of stress: Experience and determinants of food insecurity in an Inuit community. Geogr J. 2011; 177(1):44–61. https://doi.org/10.1111/j.1475-4959.2010.00374.x PMID: 21560272

70. Tam BY, Gough WA, Edwards V, Tsuji LJS. Seasonal and weather-related behavioral effects among urban Aboriginal, urban non-Aboriginal, and remote Aboriginal participants in Canada. Popul Environ. 2013; 35:45–67.

71. Delisle S, Turner S. 'The weather is like the game we play': Coping and adaptation strategies for extreme weather events among ethnic minority groups in upland northern Vietnam. Asia Pac Viewp. 2016; 57(3):351–64.

72. Hadley C, Patil CL. Seasonal Changes in Household Food Insecurity and Symptoms of Anxiety and Depression. Am J Phys Anthropol. 2008; 135:225–32. https://doi.org/10.1002/ajpa.20724 PMID: 18046777

73. Uganda Bureau of Statistics. National population and housing census: Provisional results. 2014.

74. Zaninka P. The impact of (forest) nature conservation on indigenous peoples: the Batwa of south-western Uganda—A case study of the Mgahinga and Bwindi Impenetrable Forest Conservation Trust. Case Study 5: Uganda. 2001.

75. Namara A. Assessing challenges and opportunities for participation of forest dependent Indigenous peoples and local communities in FIP design and implementation. 2016.

76. Clark S, Berrang-Ford L, Lwasa S, Namanya DB, Edge VL, Harper S. The burden and determinants of self-reported acute gastrointestinal illness in an Indigenous Batwa Pygmy population in southwestern Uganda. Epidemiol Infect. 2015 Aug 11; 143(11):2287–98. https://doi.org/10.1017/S0950268814003124 PMID: 25500189

77. Donnelly B, Berrang-Ford L, Labbé J, Twesigomwe S, Lwasa S, Namanya DB, et al. Plasmodium falciparum malaria parasitaemia among indigenous Batwa and non-indigenous communities of Kanungu district, Uganda. Malar J. 2016 Dec 4; 15(1):254. https://doi.org/10.1186/s12936-016-1299-1 PMID: 27146298

78. Namanya DB. Comparative study of malaria risk factors and access to healthcare services by Batwa and non-Batwa communities in Kanungu district southwestern Uganda. Master's thesis. International Health Sciences University, Institute of Health Policy and Management; 2013.

79. Patterson KA, Yang S, Sargeant J, Lwasa S, Berrang-Ford L, Kesande C, et al. Socio-demographic associations with pregnancy loss among Bakiga and Indigenous Batwa women in Southwestern Uganda. Sexual & Reproductive Healthcare. 2022 Jun 1; 32:100700. https://doi.org/10.1016/j.srhc.2022.100700 PMID: 35220104

80. Sauer J, Berrang-Ford L, Patterson K, Donnelly B, Lwasa S, Namanya D, et al. An analysis of the nutrition status of neighboring Indigenous and non-Indigenous populations in Kanungu District, southwestern Uganda: Close proximity, distant health realities. Soc Sci Med. 2018; 217:55–64. https://doi.org/10.1016/j.socscimed.2018.09.027 PMID: 30296691

81. Labbé J, Ford JD, Berrang-Ford L, Donnelly B, Lwasa S, Bambaiha Namanya D, et al. Vulnerability to the health effects of climate variability in rural southwestern Uganda. Mitig Adapt Strateg Glob Chang. 2016; 21:931–53.

82. Ford JD, Zavaleta-Cortijo C, Ainembabazi T, Anza-Ramirez C, Arotoma-Rojas I, Bezerra J, et al. Interactions between climate and COVID-19. Lancet Planet Health. 2022 Oct 1; 6(10):e825–33. https://doi.org/10.1016/S2542-5196(22)00174-7 PMID: 36208645

83. Ford JD, Sherman M, Berrang-Ford L, Llanos A, Carcamo C, Harper S, et al. Preparing for the health impacts of climate change in Indigenous communities: The role of community-based adaptation. Global Environmental Change. 2018 Mar; 49:129–39.

84. Kirmayer LJ, Valaskakis GG. Healing Traditions: The Mental Health of Aboriginal Peoples in Canada. Kirmayer LJ, Valaskakis GG, editors. UBC Press; 2009. xiv.

85. Charmaz K. Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis. Sage Publications; 2006. 208 p.

86. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006; 3(2):77–101.

87. Fereday J, Muir-Cochrane E. Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. Int J Qual Methods. 2006; 5(1):80–92.

88. Creswell JW, Miller DL. Determining validity in qualitative inquiry. Theory Pract. 2000; 39(3):124–30.

89. Pourmotabbed A, Moradi S, Babaei A, Ghavami A, Mohammadi H, Jalili C, et al. Food insecurity and mental health: a systematic review and meta-analysis. Public Health Nutr. 2020; 23(10):1778–90. https://doi.org/10.1017/S136898001900435X PMID: 32174292

90. Cianconi P, Betrò S, Janiri L. The impact of climate change on mental health: A systematic descriptive review. Front Psychiatry. 2020; 11:74. https://doi.org/10.3389/fpsyt.2020.00074 PMID: 32210846

91. Palinkas LA, Wong M. Global climate change and mental health. Curr Opin Psychol. 2020 Apr 1; 32:12–6. https://doi.org/10.1016/j.copsyc.2019.06.023 PMID: 31349129

92. Natamba BK, Mehta S, Achan J, Stoltzfus RJ, Griffiths JK, Young SL. The association between food insecurity and depressive symptoms severity among pregnant women differs by social support category: a cross-sectional study. Matern Child Nutr. 2017; 13(3):e12351. https://doi.org/10.1111/mcn.12351 PMID: 27507230

93. Garcia J, Hromi-Fiedler A, Mazur RE, Marquis G, Sellen D, Lartey A, et al. Persistent household food insecurity, HIV, and maternal stress in Peri-Urban Ghana. BMC Public Health. 2013 Dec 11; 13:215. https://doi.org/10.1186/1471-2458-13-215 PMID: 23497026

94. Szanton SL, Gill JM, Allen JK. Allostatic load: A mechanism of socioeconomic health disparities? Biol Res Nurs. 2005; 7(1):7–15. https://doi.org/10.1177/1099800405278216 PMID: 15919999

95. Beckie TM. A systematic review of allostatic load, health, and health disparities. Biol Res Nurs. 2012; 14(4):311–46. https://doi.org/10.1177/1099800412455688 PMID: 23007870

96. FAO. National gender profile of agriculture and rural livelihoods—Uganda. Country Gender Assessment Series, Kampala. Kampala; 2018.

97. Kruger LM, Lourens M. Motherhood and the "Madness of Hunger": ". . .Want Almal Vra vir My vir 'n Stukkie Brood" (". . .Because Everyone Asks Me for a Little Piece of Bread"). Cult Med Psychiatry. 2016; 40:124–43.

98. Grote NK, Bridge JA, Gavin AR, Melville JL, Iyengar S, Katon WJ. A Meta-analysis of Depression During Pregnancy and the Risk of Preterm Birth, Low Birth Weight, and Intrauterine Growth Restriction. Arch Gen Psychiatry. 2010 Oct 4; 67(10):1012–24. https://doi.org/10.1001/archgenpsychiatry.2010.111 PMID: 20921117

99. Arunda MO, Agardh A, Asamoah BO. Survival of low birthweight neonates in Uganda: analysis of progress between 1995 and 2011. BMC Pregnancy Childbirth. 2018; 18:189. https://doi.org/10.1186/s12884-018-1831-0 PMID: 29843626

100. Müller C, Waha K, Bondeau A, Heinke J. Hotspots of climate change impacts in sub-Saharan Africa and implications for adaptation and development. Glob Chang Biol. 2014 Aug 1; 20(8):2505–17. https://doi.org/10.1111/gcb.12586 PMID: 24796720

101. Magrath J. Turning up the heat: Climate change and poverty in Uganda. Oxfam Policy and Practice: Agriculture, Food and Land. 2008; 8:96–125.

102. Anyah RO, Qiu W. Characteristic 20th and 21st century precipitation and temperature patterns and changes over the Greater Horn of Africa. International Journal of Climatology. 2012 Mar 15; 32 (3):347–63.

103. Christensen JH, Kumar KK, Aldrian E, An SI, Cavalcanti IFA, De Castro M, et al. Climate phenomena and their relevance for future regional climate change. In: Stocker TF, Qin D, Plattner GK, Tignor M, Allen SK, Boschung J, et al., editors. Climate Change 2013: The Physical Science Basis Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; 2013.

104. Niang I, Ruppel OC, Abdrabo MA, Essel A, Lennard C, Padgham J, et al. Africa. In: Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, et al., editors. Climate Change 2014: Impacts, Adaptation and Vulnerability Part B: Regional aspects Contributions of the Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press; 2014. p. 1199–265.

105. Ford JD, Smit B, Wandel J. Vulnerability to climate change in the Arctic: A case study from Arctic Bay, Canada. Global Environmental Change. 2006 May 1; 16(2):145–60.

106. Stephens C, Porter J, Nettleton C, Willis R. Disappearing, displaced, and undervalued: a call to action for Indigenous health worldwide. The Lancet. 2006 Jun 17; 367(9527):2019–28.

107. Satyal P, Byskov MF, Hyams K. Addressing multi-dimensional injustice in indigenous adaptation: the case of Uganda's Batwa community. Clim Dev. 2020 Oct 15.

108. United Nations General Assembly. Transforming our world: the 2030 Agenda for Sustainable Development. Geneva, Switzerland; 2015.

109. The Republic of Uganda Ministry of Water and Environment. Uganda National Climate Change Policy [Internet]. 2015 [cited 2024 Jul 14]. Available from: https://www.mwe.go.ug/sites/default/files/library/National%20Climate%20Change%20Policy%20April%202015%20final.pdf.

110. United Nations Environment Programme. Uganda to Tackle Climate Crisis with National Adaptation Plan [Internet]. [cited 2024 Jul 14]. Available from: https://www.unep.org/gan/news/press-release/uganda-tackle-climate-crisis-national-adaptation-plan.